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(71) Applicant *(for all designated States except US)*: CONTRACTOR TOOLS AB [SE/SE]; P.O. Box 211, S-923 24 Storuman (SE).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: JIBBEN, Carel [SE/SE]; Röbrostigen 4 B, S-923 32 Storuman (SE).

(74) Agents: ONN, Thorsten et al.; AB Stockholms Patentbyrå, Zacco & Bruhn, P.O. Box 23101, S-104 35 Stockholm (SE).

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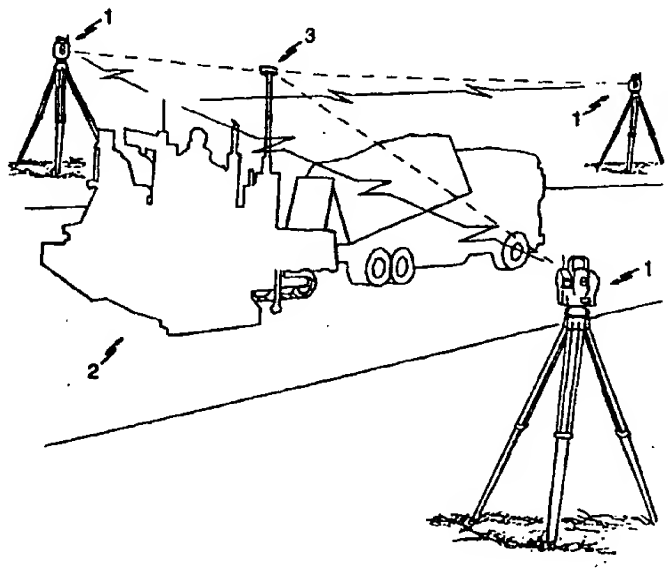

(57) Abstract

A method for remotely controlling one or more working machines (2), for instance road grading machines, asphalting machines or like machines, with the aid of one or more target-seeking total stations (1) set-up at one or more defined places, and also with the aid of reflectors (3) in the form of a ring of cube-corner prisms mounted on respective machines. One or more sectors of the reflector (3) are activated in a manner which will cause the target-seeking total station (1) or total stations to adapt its/their control function or functions.

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A METHOD AND A DEVICE FOR REMOTE CONTROLLING OF ONE OR MORE WORKING MACHINES

The present invention relates to a method and to a device for the remote control of one or more working machines, such as road grading machines, asphalting machines or like machines, in accordance with the preamble of Claims 1 and 5 respectively.

Remote control systems for working machines of the aforesaid kind are commercially available and reference is made in this regard to International Patent Application No. PCT/SE93/00617 with the same Applicant as that of the instant Patent Application. Such a system enables the operative or working units to be controlled automatically to work surfaces of any geometrical shape whatsoever. Such a surface - the target surface - may be a road surface, the surface of an airfield runway, the surface of a building site, etc. The surface to be machined will not normally be flat, but have a three-dimensional topography. The working machine can be controlled automatically on the basis of positional information obtained with the aid of one or more target-seeking total stations that are located on specific sites in the working area, one such station having the function of an automatic geodimeter. The total station or stations detects or detect the position of a reflector on the machine and transmits or transmit to the machine-controlling information via radio signals, as described in the aforesaid International Patent Application. As will be understood, positioning becomes less accurate the further the working machine moves away from the target-seeking or scanning total station. For this reason, it has been found necessary when constructing, for instance, aircraft runways and roads, highways, etc., to position several target-seeking total stations along the building site and enable several machines to work simultaneously. As this work is in progress, there is always a risk that the reflector on one machine will obstruct the path of the energy beam

from a target-seeking total station that controls another machine at that moment in time. This total station is therewith liable to lock onto the new machine, which is highly undesirable of course. It is also desirable to be able to exchange a machine-controlling total station simply and automatically, as the machine moves along or around the construction site.

It is known to use on such machines reflectors in the form of cube-corner prisms which are disposed in a ring generally in a plane parallel with the direction of movement of the machine. It is impossible to prevent a total station from locking inadvertently onto such a reflector or, without deactivating the total station, to replace the total station operating with this machine for another.

The invention enables several machines which work independently of one another on a construction site to be readily controlled by activating a respective reflector. This is made possible by virtue of the features characteristic of the invention as defined in the Claims.

The invention will now be described in more detail with reference to the accompanying drawings, in which Fig. 1 illustrates the control of an asphalting machine with the aid of the control system; Fig. 2 illustrates schematically the principle of a known reflector device comprised of cube-corner prisms; Fig. 3 is a schematic sectional view of the inventive reflector taken on the line III-III in Fig. 4, this sectional view being only partially complete; Fig. 4 is a side view of the inventive reflector; Fig. 5 illustrates a part of the reflector; Fig. 6 illustrates a variant of the inventive reflector in a view taken on the plane VI-VI in Fig. 7; Fig. 7 is a side view of this reflector; and Fig. 8 is a partial view which illustrates schematically a further variant of the inventive reactor according to Fig. 7.

Fig. 1 illustrates schematically the application of a control system according to the aforesaid International Patent Application, in which three target-seeking or target-scanning total stations 1 are positioned at known places in space, for instance on a road or highway that is to be constructed. In the illustrated case, the control machine is an asphalting machine 2 which is provided with a reflector 3 in accordance with the invention. The total station or total stations 1 reads-off or read-off the position of the working machine through the medium of the reflector 3 and steer the machine with the aid of radio signals. The control system as such, however, does not form part of the present invention and will not therefore be described in detail here. Instead, the reader is referred to the aforesaid International Patent Application.

As before mentioned, the machine-carried reflector is comprised of a number of cube-corner prisms 4, see Fig. 2, which are disposed in mutually adjacent relationship to form a ring. A cube-corner prism is able to reflect light in the same direction as the angle of incidence, irrespective of movement of a light source within a given angular range of the prism. The range within which this reflection takes place - the re-reflection angular range - is referenced ß in Fig. 2 and is normally about 60°. The angle regions ß of mutually adjacent prisms 4 overlap one another, so as to obtain reliable reflection from the reflector 3. In the illustrated case, the reflector includes seven cube-corner prisms. Each angle overlap is about 5°, which provides a positive re-reflection angle range α for each prism, the angle range α being slightly greater than 51°. Naturally, the re-reflection angle range of the prisms in the vertical plane will also be equal to ß. The use of cube-corner prisms and their arrangement in accordance with the aforegoing provides a very reliable reflector that can be used in conjunction with earth-working equipment, for instance.

Fig. 3 is a sectional view taken on the line III-III from above in Fig. 4 and illustrates the principle of one embodiment of an inventive reflector. The prisms are located above the section in the form shown in Fig. 2. Fig. 4 is a schematic side view of the inventive reflector. The reflector is carried on the machine by means of a rod or staff 5 with the cube-corner prisms 4 mounted in the reflector in some appropriate manner, for instance with the aid of upper and lower collars 9 and 10 respectively. One or more cube-corner prisms can be selectively "deactivated", by screening-off one or more prisms or a sector of prisms, i.e. so that the reflector is unable to reflect light in a given direction or directions. To this end, there is mounted in front of each prism 4 a pivotal flap 11, wherein Fig. 4 illustrates in full lines one flap in an upwardly pivoted position and in broken lines a downwardly swung position in which the prism is exposed. The flap is pivotal about a shaft 12. For the sake of clarity, Fig. 4 shows only one flap. The flap 11 is pivoted by means of an electric motor 14 through the medium of a worm gear or wheel 13.

Fig. 3 shows the flaps 11 and their drive means, although not all have been shown for the sake of simplicity. The flaps are pivotal in their own plane, and the vertical edges thereof are bevelled so as to enable adjacent flaps to pass freely relative to one another, as indicated at 15 in Fig. 3.

Fig. 5 illustrates a flap 11 and a flap drive motor 14 on a larger scale. Fixedly mounted on the lower collar 10 is a shaft pivot 16, which is screwed to the collar, for instance. The flap 11 is carried by the worm wheel 13 through the medium of a hollow shaft 17. A spacing sleeve 18 is fitted between the collar 10 and the worm wheel 13, and the flap and worm wheel are fixed axially by means of a locking ring 19. It will be understood that the illustrated flap drive mechanism is only one example of a simple, mechanical drive mechanism. It is also conceivable to arrange the prisms so

that the prisms can be swung independently out of the reflection plane, or alternatively so that the prisms can be lowered behind a screen. These solutions, however, are thought to be less attractive because of the high stresses to which the reflector is subjected. It is emphasized that the structural solution used to move the flaps and to mount and secure the cube-corner prisms form no part of the invention itself.

Another method of preventing a target-seeking total station from registering the current positional values of a reflector and sending these values to the machine with the purpose of controlling said machine, is to cause one or more sectors of the reflector facing towards the total station to send a signal thereto. The reflector may, to this end, be provided with light-emitting diodes which transmit IR-light at an accurately determined frequency, this light being received by receiver optics in the total station. The IR-light emitted by a light-emitting diode shall have the same directional sense as a dedicated or allocated cube-corner prism. The given field of view λ of the light-emitting diode will include an angle of about 28°. Compared with the earlier mentioned re-reflection angle range α = 51° of the cube-corner prism, it is therefore necessary to allocate to each cube-corner prism two light-emitting diodes which together will provide a covering angle greater than 50°. Figs. 6 and 7 illustrate a practical embodiment of an inventive reflector unit provided with light-emitting diodes, there being used seven cube-corner prisms 4 and fourteen light-emitting diodes 20 which are disposed in a ring at a given distance in relation to the centre of the cube-corner prism 3 and transmit IR-light at an accurately determined frequency. In the Fig. 6 embodiment, the light-emitting diodes 20′ and 20" have been allocated to the cube-corner prism 4′.

Figs. 6 and 7 thus show a reflector provided with diodes relative to the reflector shown in the previous Figures. In

the Fig. 6 illustration, the cube-corner prisms 4 have been angled in relation to one another at an angle of about 50° and moved outwards radially in comparison with the earlier described reflector. The reflection principle of the cube-corner prisms 4 of this arrangement, however, is the same as that of the Fig. 2 arrangement. The form of this reflector is governed by the precise position of the two light-emitting diodes allocated to each prism, this position of the diodes being determined by the position of the IR-light receiver optic of the total station.

Because the two light-emitting diodes (for instance 20' and 20") are allocated to the cube-corner prism 4' which, at that moment, is directed towards the target-seeking total station, the diodes will send their intensity modulated signals (light frequency) to the total station and the signals from one of the diodes will be received by the receiver optics in the total station, which therewith locks onto the reflector and steers the machine. By extinguishing the two light-emitting diodes 20', 20" allocated to the prism 4', the total station can be prevented from measuring the current positional values of the reflector and no control signals will be sent to the machine. The light-emitting diodes on the reflector can be switched-off by remote control (radio signals, light signals). It is therewith possible to activate and deactivate the machine control of a target-seeking total station, for instance because the position of the station in relation to the machine has become critical or because another total station shall be prevented from locking onto the machine, and so on.

Because the light-emitting diodes require a given amount of space, it is difficult to provide room for the diodes in the reflector in the position determined exactly by the total station in relation to the allocated cube-corner prism. This drawback can be overcome by instead using mirrors or mirror prisms in the position determined in relation to the

cube-corner prism, wherewith the light-emitting diodes can be placed closer to the vertical axis of the reflector, meaning that the prisms are placed closer to the axis and the angular errors of the angles measured by the total station are eliminated. Fig. 8 illustrates schematically an example of the use of prisms 21 having reflective hypotenuses disposed in the specific positions from which IR-light shall be emitted from the reflector. The diodes 20 themselves are placed in a ring below the prisms. Fig. 8 merely illustrates an example of the use of mirrors, in this case in the form of prisms, and the mirror surfaces may, of course, be turned in other ways which will permit different positioning of the light-emitting diodes, while several mirrors may be used for one and the same diode, therewith affording more flexibility with regard to the positioning of the diodes.

CLAIMS

1. A method for remotely controlling one or more working machines (2), for instance road grading machines, asphalting machines or like machines, with the aid of one or more target-seeking total stations (1) set-up at one or more defined places, and also with the aid of reflectors (3) in the form of a ring of cube-corner prisms mounted on respective machines, characterized by activating one or more sectors of the reflector (3) so that the target-seeking total station (1) or total stations relevant to controlling the machine (2) is caused to adapt its control function by the machine (2).

2. A method according to Claim 1, characterized in that said activation is achieved by virtue by actuating the target-seeking total station a signal emitter for the sector or sectors concerned.

3. A method according to Claim 1, characterized in that said activation is achieved by virtue of screening a sector or sectors of the reflector.

4. A method according to Claim 1, characterized in that said activation is achieved by swinging the reflector sector or sectors out of the given reflection plane.

5. A reflector for earth-working machines whose working functions are controlled or steered by one or more target-seeking total stations (1) whose positions in space are known and which can be locked optically onto the reflector (3) carried by the earth-working machine, wherein the reflector is comprised of cube-corner prisms (4) disposed in a ring which lies in a plane generally parallel to the plane in which the machine moves, characterized in that there is mounted adjacent a respective cube-corner prism (4) a device (11) which is capable of interrupting the intended control

of said machine from the total station.

6. A reflector according to Claim 5, characterized in that said device is comprised of light-emitting diodes (20) which transmit to the total station IR-light in the form of intensity modulated signals.

7. A reflector according to Claim 6, characterized in that the IR-light is transmitted through the medium of a mirror located after an allocated light-emitting diode.

8. A reflector according to Claim 5, characterized in that said device has the form of a flap (11) which can be swung to a position in front of its cube-corner prism (4) so as to obstruct its reflecting ability.

9. A reflector according to Claim 5, characterized in that respective cube-corner prisms (4) can be moved individually out of the plane through the ring of prisms.

10. A reflector according to any one of Claims 5-9, characterized in that the device which functions to interrupt locking of the total station onto the cube-corner prism can be activated by remote control.

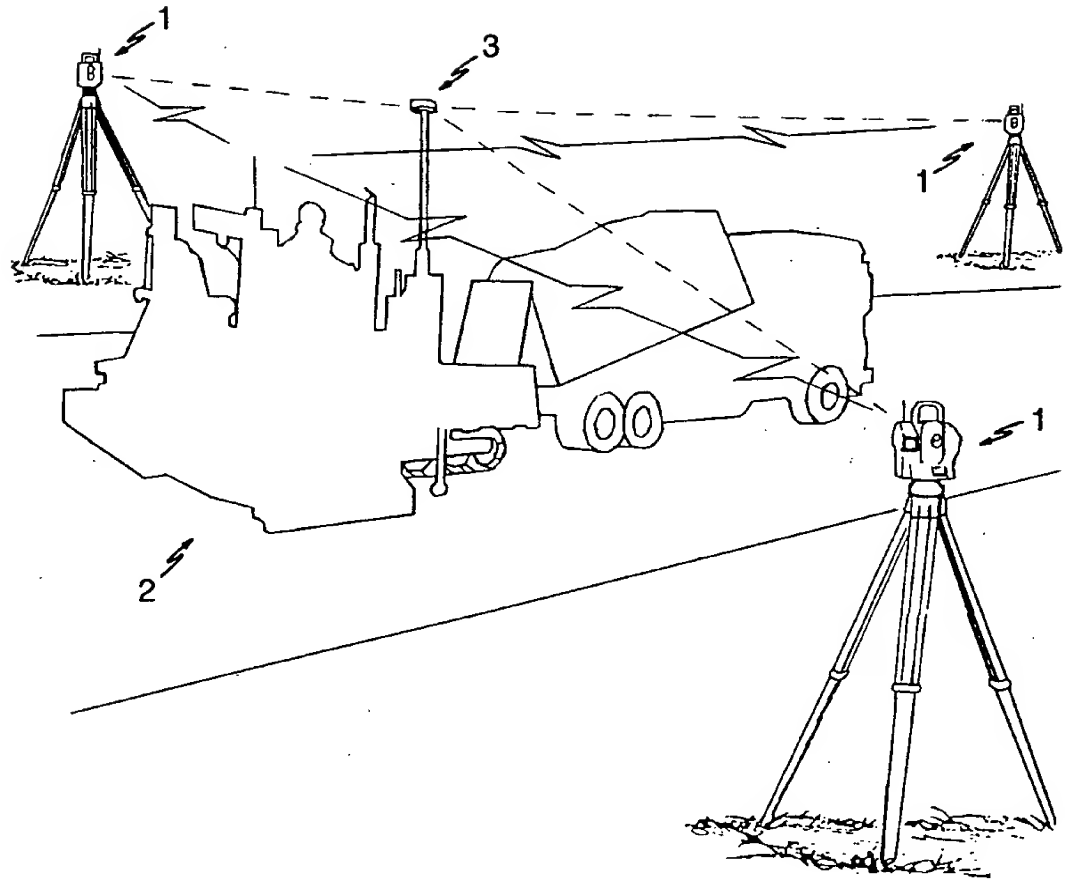

FIG.1

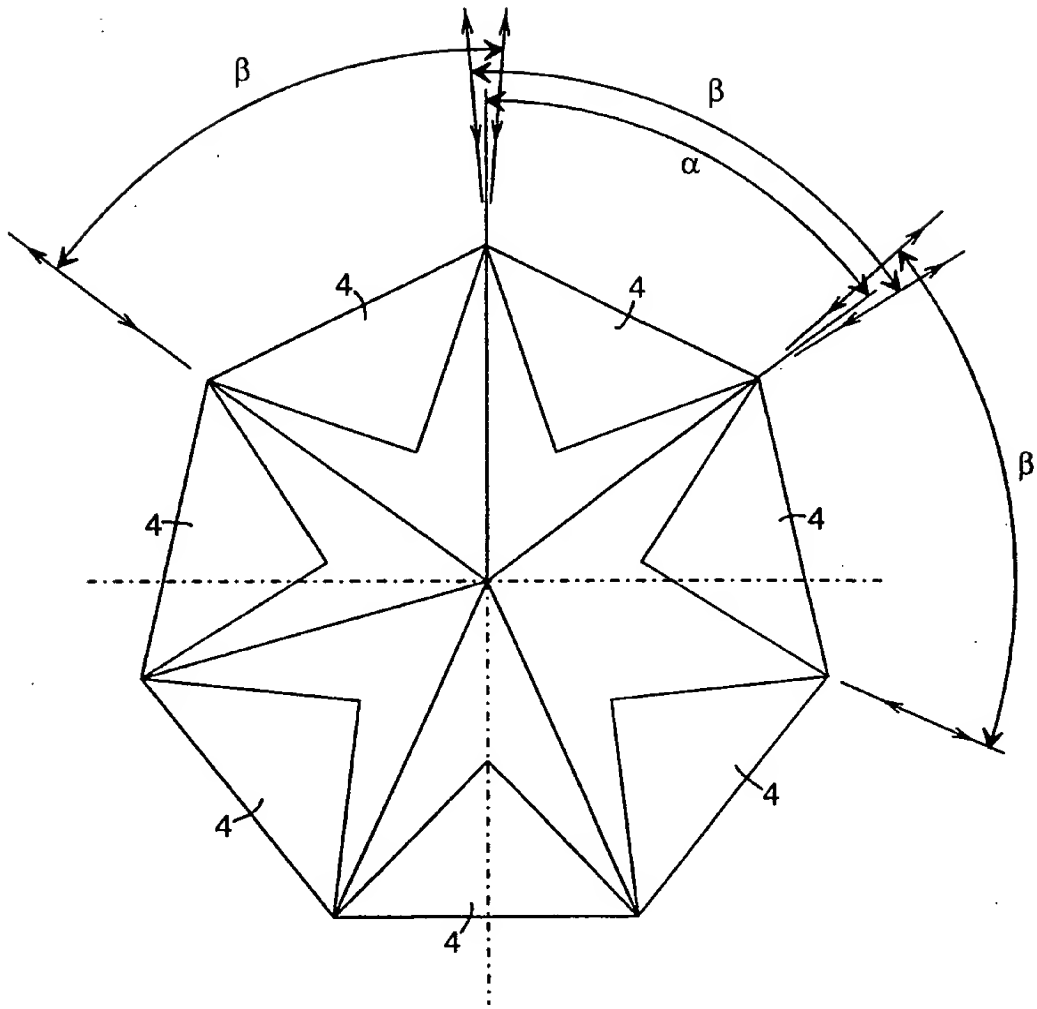

FIG.2

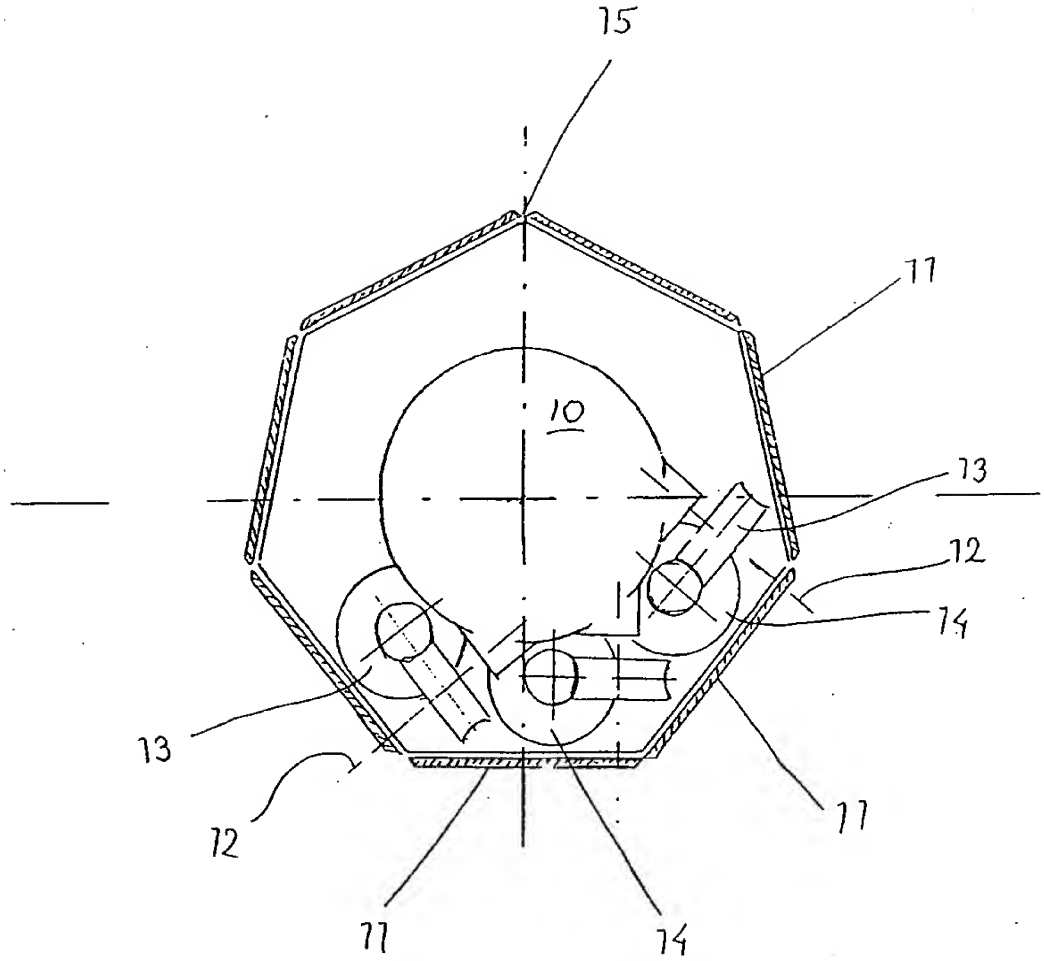

Fig 3

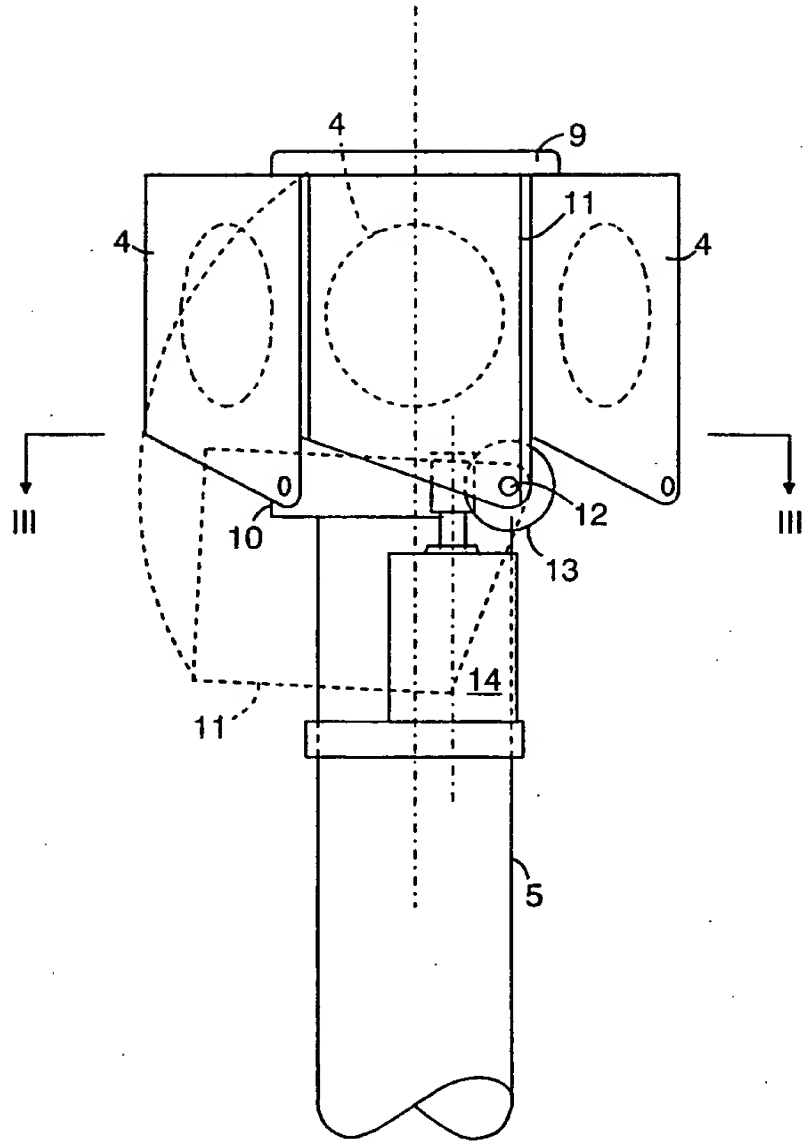

FIG.4

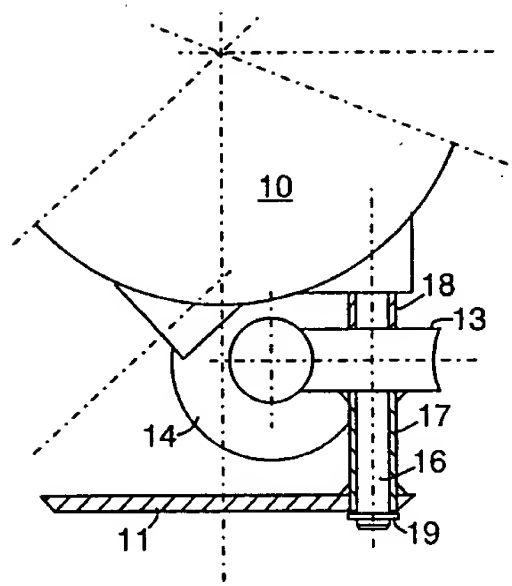

FIG.5

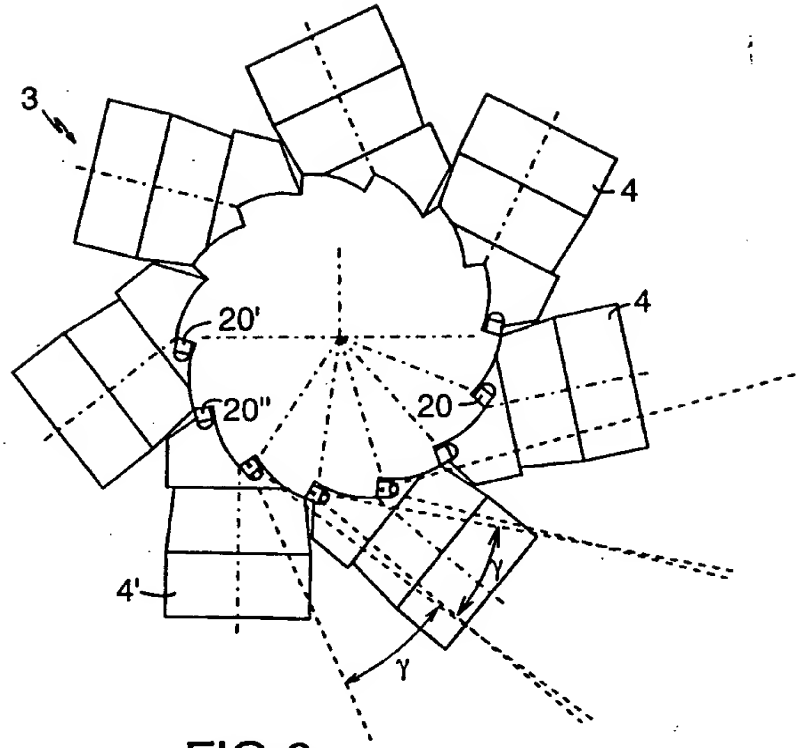

FIG.6

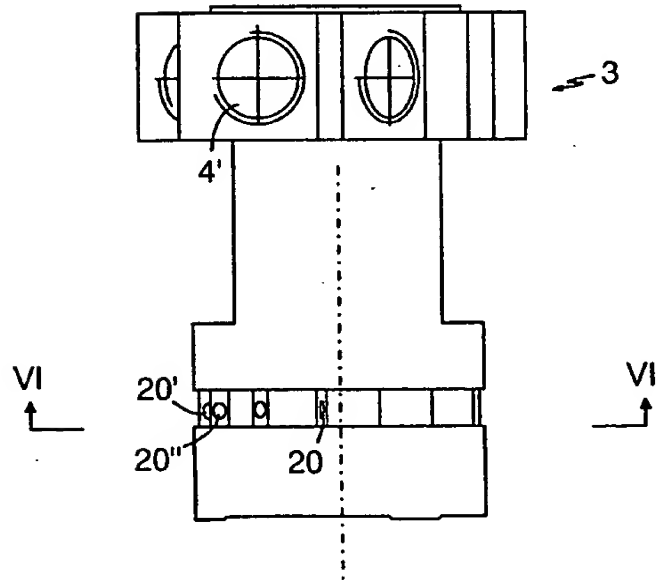

FIG.7

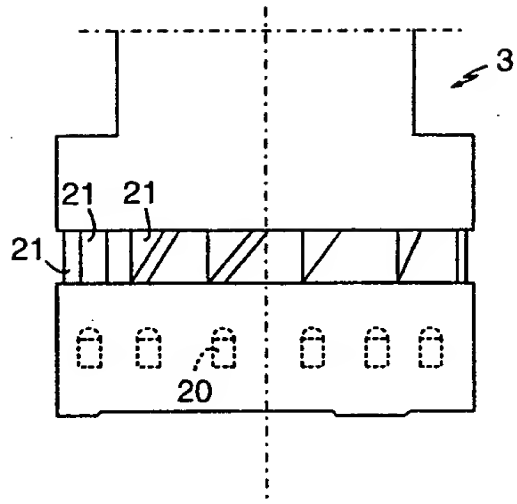

FIG.8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 95/00694

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G05D 1/00, G01S 17/02, E02F 3/84
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: G05D, G01S, E02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

DIALOG

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Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	EP 0255284 A1 (STEPHEN W. BELL), 3 February 1988 (03.02.88), abstract	1-10
A	-- EP 0269283 A1 (INSTITUTE FOR INDUSTRIAL RESEARCH AND STANDARDS), 1 June 1988 (01.06.88), figure 1, abstract	1-10
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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International application No.
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

02/10/95

International application No.

PCT/SE 95/00694

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